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TRI-SERVICE THERMAL FLASH TEST FACILITY.(U)

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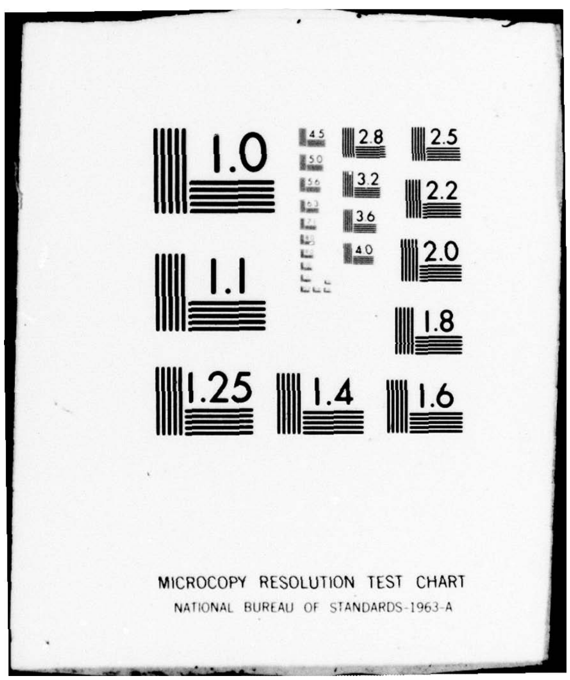
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TRI-SERVICE THERMAL FLASH TEST FACILITY

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University of Dayton
Research Institute
300 College Park Avenue
Dayton, Ohio 45469

30 November 1978

Final Report for Period 6 August 1976—31 October 1978

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the status and capabilities of the Tri-Service Thermal Nuclear Flash Test Facility. The Facility is used for investigating the effects of thermal radiation on materials. The Facility consists of several quartz lamp banks for simulating thermal radiation, a wind tunnel for simulating aerodynamic loads, and a mechanical loading device for simulating tension and bending loads, and associated instrumentation.

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PREFACE

This summary report covers work performed during the period from 6 August 1976 to 31 October 1978 under Defense Nuclear Agency contract DNA001-76-C-0339. The work was administered under the direction of Capt. J.M. Rafferty, Contracting Officer's Representative on this contract.

The following reports were generated under the same contract:

N/A

UDRI-TR-77-28, "Tri Service Thermal Radiation Test Facility: Test Procedures Handbook," May 1977.

DNA 4488Z, "Tri-Service Thermal Flash Test Facility," Interim Summary Report, 29 March 1978. UDR-TR-77-72 A056 321

The work was conducted under the general supervision of Mr. Dennis Gerdeman and the principal investigator was Dr. Ronald A. Servais. The test engineer was Mr. Benjamin H. Wilt and the research technician was Mr. Nicholas J. Olson.

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SECTION 1
INTRODUCTION

1.1 BACKGROUND

The degradation of materials exposed to the intense radiation heating generated by a nuclear blast can vary enormously. The performance of materials exposed to intense radiation heating can be observed in the laboratory; the results of these tests can be utilized by design engineers to match material performance with design requirements.

The University of Dayton has extensive experience in materials development and materials performance testing. Since the 1950's, the University of Dayton has been involved with testing and evaluating the performance of materials exposed to high thermal inputs, particularly for U.S. Air Force applications. These efforts have included the development and operation of the required laboratory facilities.

In 1976, the Defense Nuclear Agency contracted with the University of Dayton to establish and operate a thermal flash test facility for conducting tests on materials for the Tri-Services community. The facility was to be located at the USAF Materials Laboratory, Wright-Patterson Air Force Base, Ohio 45433.

1.2 OBJECTIVES

The primary objectives of the research activity can be summarized:

(1) To continue to provide the Tri-Service community with a quick-response intense radiation heating experimental capability, including the effects of aerodynamic and mechanical loads;

(2) To conduct tests for the Tri-Service community as required; and

(3) To maintain, improve, and modify the test facility between scheduled tests.

SECTION 2

TRI-SERVICE NUCLEAR FLASH TEST FACILITY

2.1 OVERVIEW

The original development of the Tri-Service Nuclear Flash Test Facility is described in Reference 1. The Facility has four basic experimental capabilities at the present time:

(1) Irradiation of test specimens using a Quartz Lamp Bank (QLB);

(2) Irradiation of test specimens using a QLB in aerodynamic flow;

(3) Irradiation of test specimens using a QLB with tension or bending mechanical loads; and

(4) Irradiation of test specimens using an Arc Imaging Furnace (AIF).

The Facility layout is illustrated in Figure 1.

Available instrumentation include radiometers for determining heat flux, thermocouples for monitoring temperatures, a pitot tube for determining flow velocities, strain gages, still and movie cameras, X-Y recorders, and various electronic control devices. Limited machining facilities are available for minor specimen modification or alteration during test programs.

2.2 NUCLEAR FLASH SIMULATION

2.2.1 Quartz Lamp Banks

The intense radiation needed to simulate a nuclear flash can be produced by a series or bank of tungsten filament, quartz lamps. Three banks are available in the Facility; they are designated the Stationary Quartz Lamp Bank (SQLB), the Mobile Quartz Lamp Bank (MQLB), and the High Density Lamp Bank (HDLB). The operational characteristics of the banks are listed in Table 1. The SQLB is primarily used for instrumentation check-out and radiation-only exposure tests. The MQLB, shown in Figure 2, is used in conjunction with the simulation of aerodynamic or mechanical loads.

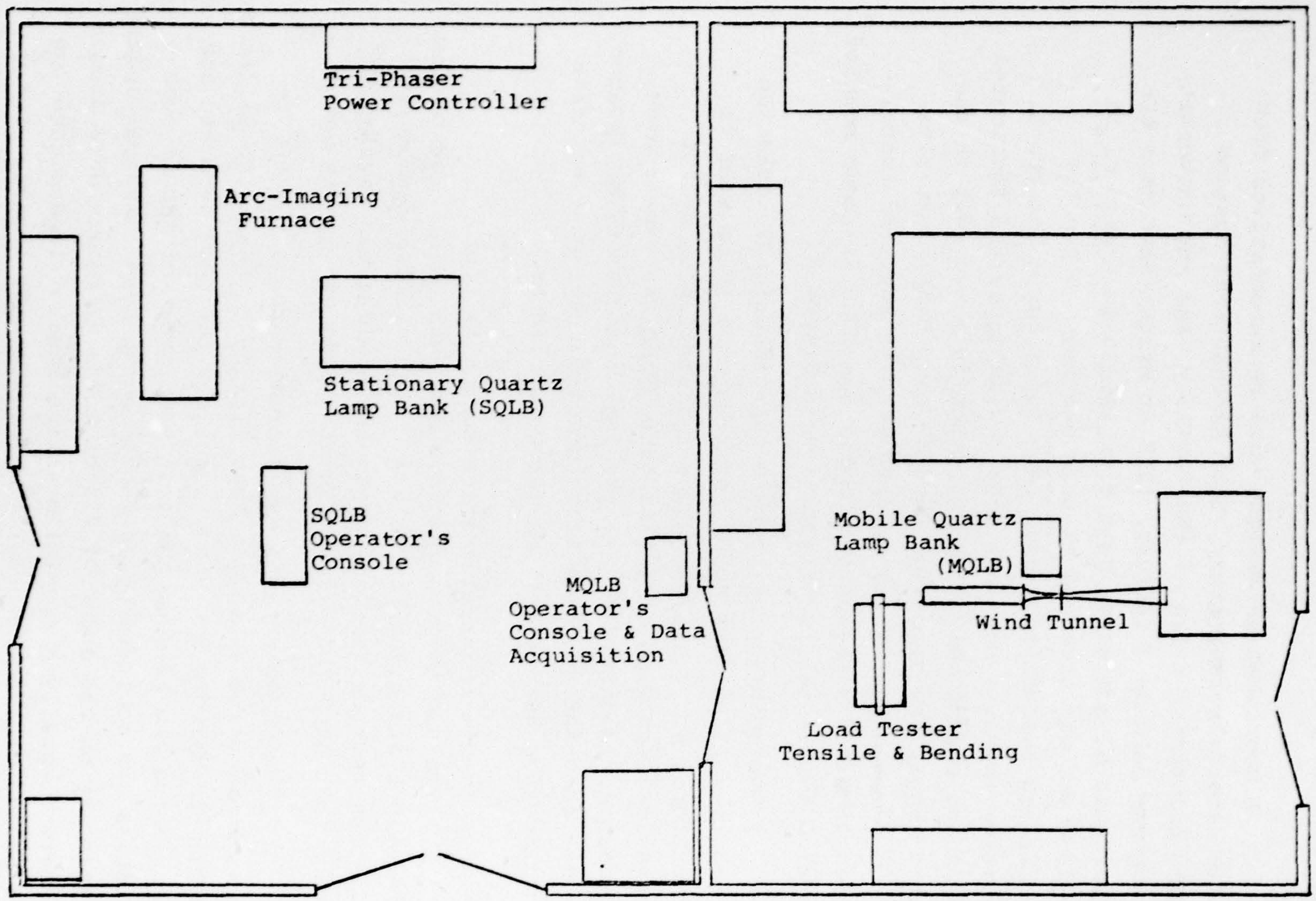

Figure 1. Tri-Service Nuclear Flash Test Facility.

A coordination meeting with representatives from DNA, USAF Materials Laboratory, USAF Aeronautical Systems Division, industrial users of the Facility, and the University of Dayton was held on 3 February 1978 at Wright-Patterson AFB. The importance of achieving heat flux levels in excess of 50 calories/cm^2sec was stressed at this meeting. Since the Stationary and the Mobile Quartz Lamp Banks could not reach this heating level, a new lamp bank was designed and fabricated. The lamps are packed very close together in three rows in the new bank, hence, the name High Density Lamp Bank; heat flux levels of 57 calories/cm^2sec on specimens in the wind tunnel have been attained with the new bank. The HDLB is shown mounted in the wind tunnel test configuration in Figure 3.

The MQLB approximates a one-dimensional radiation source 15 cm x 12 cm; the HDLB approximates a 10 cm x 12 cm one-dimensional source. The incident radiation on a test specimens is a function of the distance from the bank source, as illustrated in Figure 4. No physical constraints are placed on the maximum test specimen size; however, care must be taken to minimize edge heat losses on larger specimens.

2.2.2 Arc Imaging Furnaces

Two arc imaging furnaces are available. The furnace specifications are given in Table 2. Both utilize carbon arcs as radiation sources, thereby producing a different wavelength radiation than produced by the tungsten filament quartz lamps.

The Gaussian Beam Arc Imaging Furnace (GBAIF) is capable of producing a radiant heat flux up to about 140 cal/cm^2sec. Two parabolic mirrors are used to reflect the beam from the arc and to refocus the beam on the test specimen. Different peak intensities are achieved by de-focusing the beam. Typical specimen sizes are on the order of 2.5 cm x 2.5 cm square or 2.5 cm in diameter; usually a special mounting bracket is designed for each type of specimen in order to minimize heat losses. Exposure times may vary from 0.1 seconds to about 20 seconds; the

TABLE 1

QUARTZ LAMP BANK SPECIFICATIONS

	SQLB	MQLB	HDLB
Lamp Designation	GE/Q6M/T3/CL/HT	GE/Q6M/T3/CL/HT	GE/Q6M/T3/CL/HT
Number of Lamps	24	24	24
Lamp Bank Area	22 cm x 25 cm	22 cm x 25 cm	15 cm x 25 cm
Maximum Voltage	460 vac	460 vac	460 vac
Maximum Current	300 a	300 a	300 a

TABLE 2

ARC IMAGING FURNACE SPECIFICATIONS

Mfgr.	Model	Beam	Arc Power
Strong	66000-2	Gaussian	72 vdc, 160a
Genarco	T-ME 6-CWM	One-dimensional	75 vdc, 420a

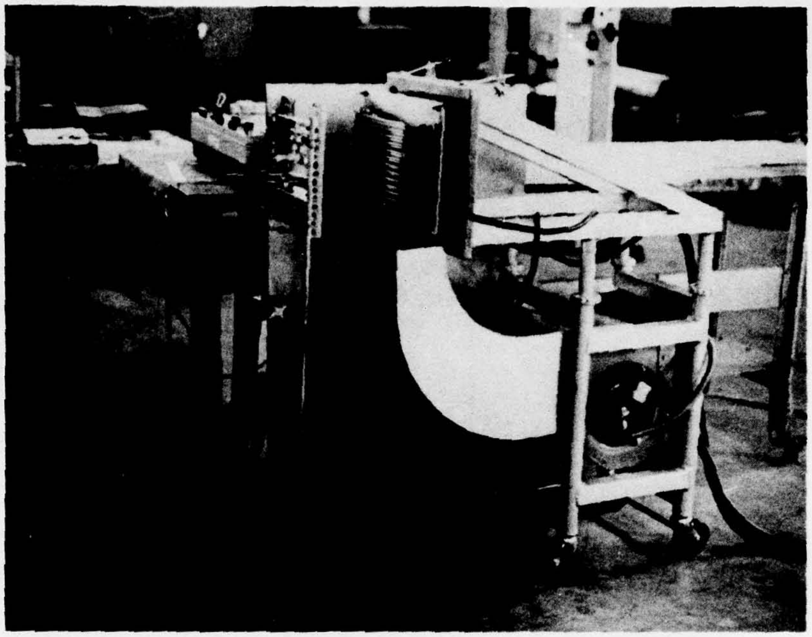

Figure 2. Mobile Quartz Lamp Bank.

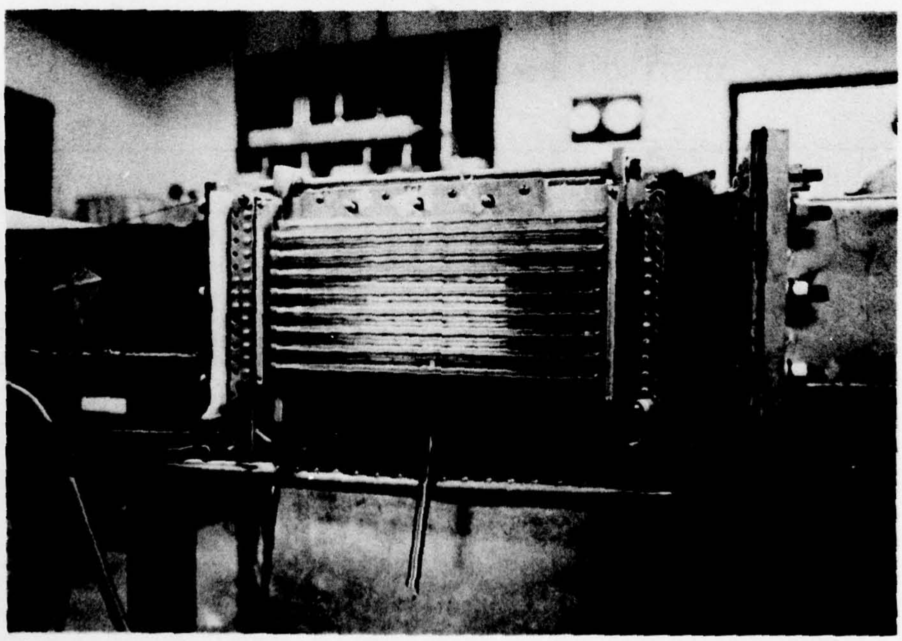

Figure 3. High Density Lamp Bank.

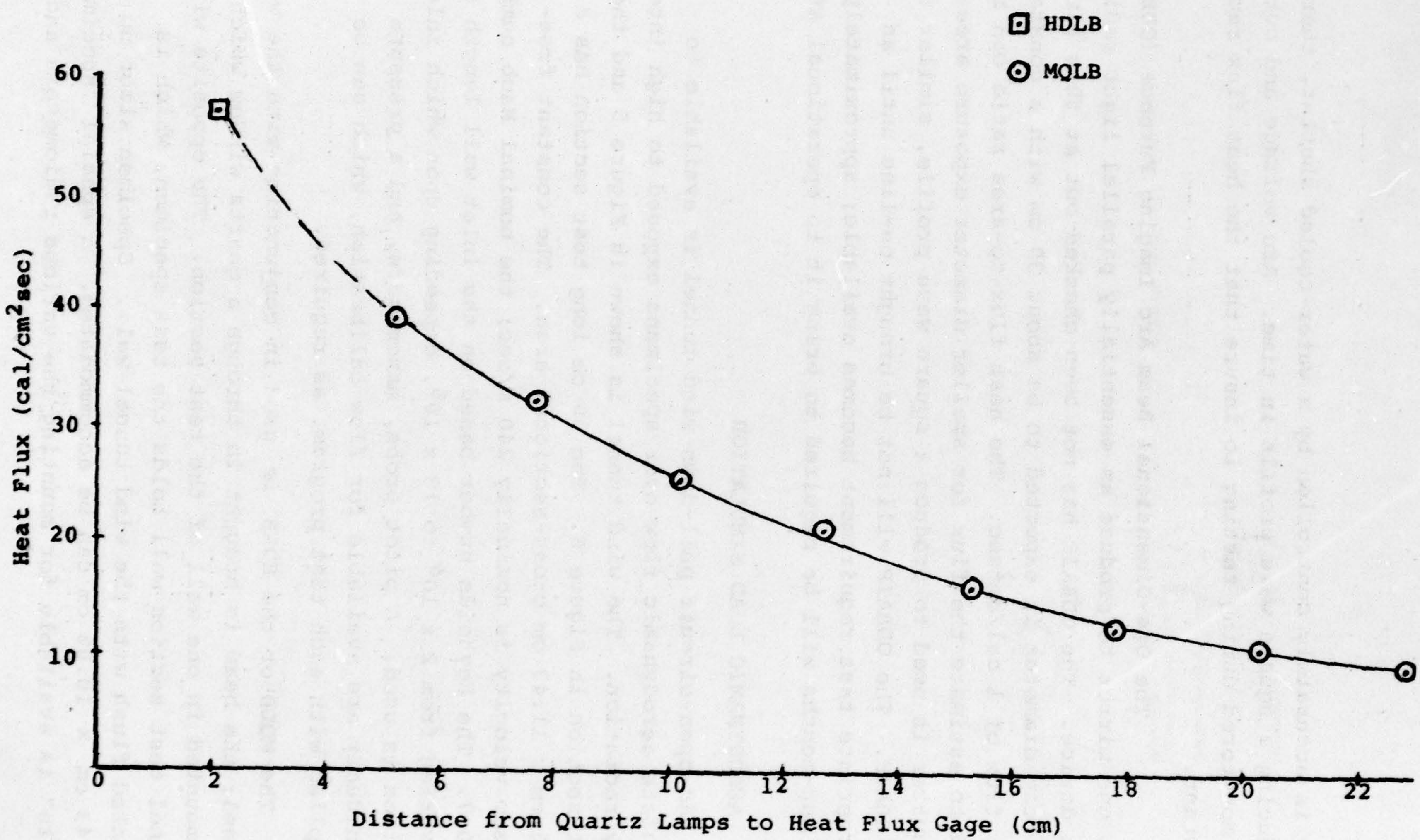

Figure 4. Radiation Heat Flux vs. Distance From Lamp Bank.

time is accurately controlled by a water-cooled shutter, thereby producing a square wave profile in time. Arc voltage and current are monitored during testing to insure that the heat flux remains constant.

The One-Dimensional Beam Arc Imaging Furnace (ODBAIF) uses one mirror to produce an essentially parallel light radiation test device. The ODBAIF has not been checked out at this time. The beam diameter is expected to be about 30 cm with a constant heat flux of 1 cal/cm^2sec. The heat flux-to-area ratio can be used to estimate the flux for smaller diameter exposure areas. A shutter is used to produce a square wave profile, similar to the GBAIF. The ODBAIF will not be brought on-line until an appropriate test requirement becomes available; approximately two man-months will be required to bring it to operational status.

2.3 AERODYNAMIC LOAD SIMULATION

An open-circuit pull-down wind tunnel is available to simulate aerodynamic flow over specimens exposed to high intensity radiation. The wind tunnel is shown in Figure 5 and the test section in Figure 6. The 30 cm long test section has a 2.38 cm x 11.43 cm cross-sectional area. The constant free-stream velocity is nominally 240 m/sec; the nominal Mach number is 0.7. The Reynolds number based on the inlet wall length can be varied from 2×10^6 to 18×10^6, depending upon which inlet section is used. A pitot probe, manometers, and a pressure transducer are available for flow calibration, which can be supplied with each test program, as required.

The MQLB or the HDLB is used in conjunction with the wind tunnel; the beam is brought in through a quartz window which is mounted in one wall of the test section. The opposite wind tunnel test section wall holds the test specimen, which is mounted flush with the wind tunnel wall. Specimen sizes up to 11.43 cm x 10.08 cm can be accommodated. A special "specimen plate" is available for mounting the various radiometers and

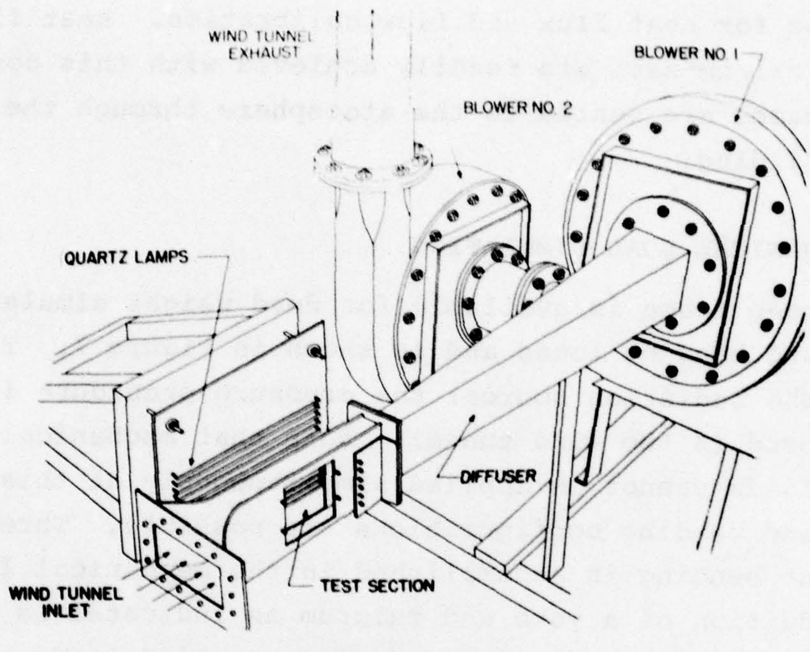

Figure 5. Wind Tunnel.

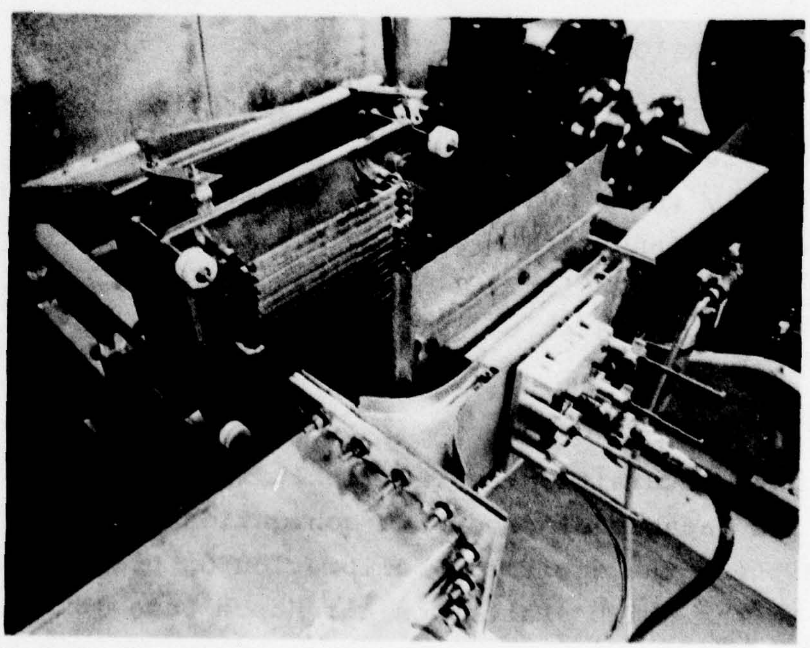

Figure 6. Wind Tunnel Test Section.

pitot tube for heat flux and flow calibration. Heat flux levels up to 57 cal/cm^{2}sec, are readily achieved with this configuration. Exhaust gases are vented to the atmosphere through the roof of the building.

2.4 MECHANICAL LOAD SIMULATION

A creep frame is available for dead weight simulation of tensile and bending loads and is shown in Figure 7. The MQLB is used as the radiation source; the exposure procedure is similar to that used in the wind tunnel. Note that mechanical and aerodynamic loads cannot be applied simultaneously at this time. Tension and bending configurations are possible. Three and four point bending is accomplished in the mechanical load frame by the addition of a yoke and fulcrum as indicated in Figure 8. Recommended specimen sizes and maximum applied loads are specified in Table 3. Strain gages and other appropriate instrumentation are mounted on test specimens in order to monitor strain as a function of time during exposure to radiation.

2.5 INSTRUMENTATION

The instrumentation required for operating the facility and which is available is summarized in Table 4. Facility users normally supply their own specimen-mounted instrumentation, such as thermocouples and strain gages. Additional details on the heat flux instrumentation and plotters which are available are given in Tables 5 and 6.

2.6 DATA ACQUISITION SYSTEM

The data acquisition system, including an LSI-11 microcomputer, is capable of producing conventional X-Y plots on-line or transmitting the digitized calibration or property data directly to the Wright-Patterson Air Force Base (WPAFB) Computing

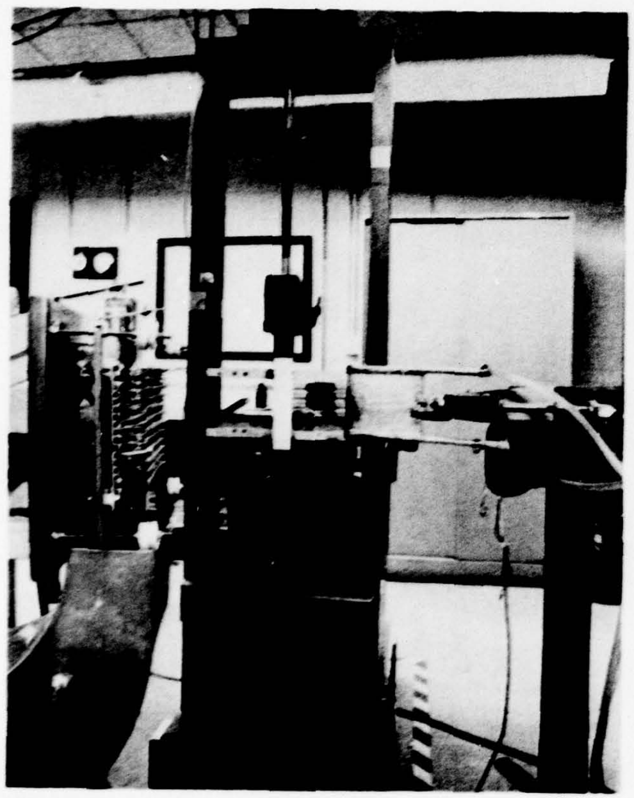

Figure 7. Mechanical Loading-Tension.

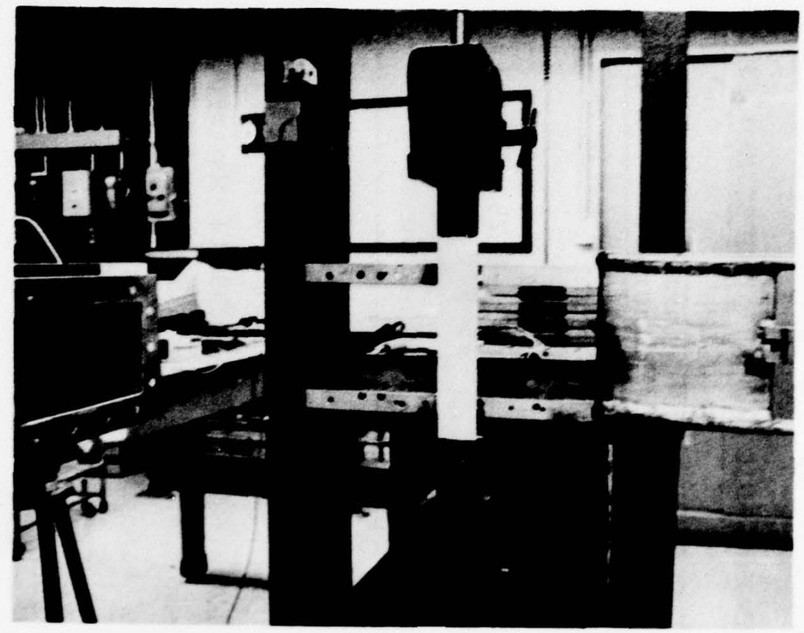

Figure 8. Mechanical Loading-Bending.

TABLE 3

RECOMMENDED MECHANICAL LOADING SPECIMEN INFORMATION

	Uniaxial Tension	Bending Tension or Compression
Specimen Size (cm)		
Width	5-7.5	5-7.5
Thickness	0.02-1.25	0.6-2.5
Length	25-60	50-75
Stress Levels (MPa)	3.5-1700	7-1400

Facility for further data reduction. The output can be in the form of tabulated or plotted and labelled data. Figure 9 schematically illustrates the system. Table 7 lists the system components. The interface between the LSI-11 and the WPAFB Computing Facility was developed by Lt. Randy Rushe and is described in Reference 2.

2.7 CONTROL SYSTEM

The primary components of the laboratory (quartz lamp banks, wind tunnel, exhaust system) can be controlled and monitored from the operator console, which is shown in Figure 10. Only one operator is required for most tests. The console is mobile and located such that the operator can visually observe a test (if appropriate) and also monitor critical voltages and currents, etc. This allows the operator to abort a test if necessary. The console also houses the microcomputer and the other components of the data acquisition system with the exception of the data terminal. Figure 11 is an overview of the mobile quartz lamp bank, the wind tunnel, and the operating console.

TABLE 4

AVAILABLE INSTRUMENTATION

Application	Quantity	Instrumentation	Purpose
Quartz Lamp Banks	6	Radiometers	Heat Flux
	1	Thermac Temperature Controller	Heat Flux Control
	1	Data-Trak Controller	Heat Flux Control
Aerodynamic Load	1	$\pm$10 psi Stathem pressure Transducer	Flow Calibration
	1	Pitot Probe Assembly	Flow Calibration
	1	Manometer	Flow Calibration
Mechanical Load	1	Wheatstone Bridge	Strain Gage
Arc Imaging Furnaces	2	Radiometers	Heat Flux
	1	Calorimeter	Heat Flux
	1	Time Controller (0.1 sec min)	Shutter Control
General	3	X-Y-Y' Recorders	Data Recording
	1	Kennedy DS-370 Tape Recorder	Data Recording
	1	LSI-11 Micro-processor	Data Recording
	1	35mm Nikon Still Camera	Specimen Photographs
	1	MP-4 Polaroid Still Camera	Specimen Photographs
	2	8mm Nizo Braun Movie Cameras	Specimen Photographs
	-	Various Thermocouples	Temperature
	1	L&N 8641-S Automatic Recording Pyrometer (760-6000°C)	Surface Temperature
	-	Barometer, Thermometer, Hygrometer	Ambient Conditions

TABLE 5

HEAT FLUX GAGE SPECIFICATIONS

Mfgr	Type	Model	Range	Accuracy
Medtherm	Gardon	64P-20-24	0-5 cal/cm^2sec	±3%
Medtherm	Gardon	64P-50-24	0-13 cal/cm^2sec	±3%
Medtherm	Gardon	64P-100-24	0-27 cal/cm^2sec	±3%
Medtherm	Gardon	64P-100-24	0-27 cal/cm^2sec	±3%
Medtherm	Gardon	64P-200-24	0-54 cal/cm^2sec	±3%
Medtherm	Gardon	64P-200-24	0-54 cal/cm^2sec	±3%
RdF	Gardon	CFR-1A	0-400 cal/cm^2sec	±10%
RdF	Gardon	CFR-1A	0-400 cal/cm^2sec	±10%
ADL	Calorimeter	---	50-350 cal/cm^2sec	±5%

TABLE 6

X-Y RECORDER SPECIFICATIONS

Mfgr	Model	Channels	Range	Response
Hewlett-Packard	7046A X-Y-Y'	2	0.2mv/cm-4v/cm	0.025-5cm/sec
Hewlett-Packard	136 X-Y-Y'	2	0.2mv/cm-20v/cm	0.05-5cm/sec
Honeywell	540 X-Y-Y'	2	0.04mv/cm-0.4v/cm	0.025-5cm/sec

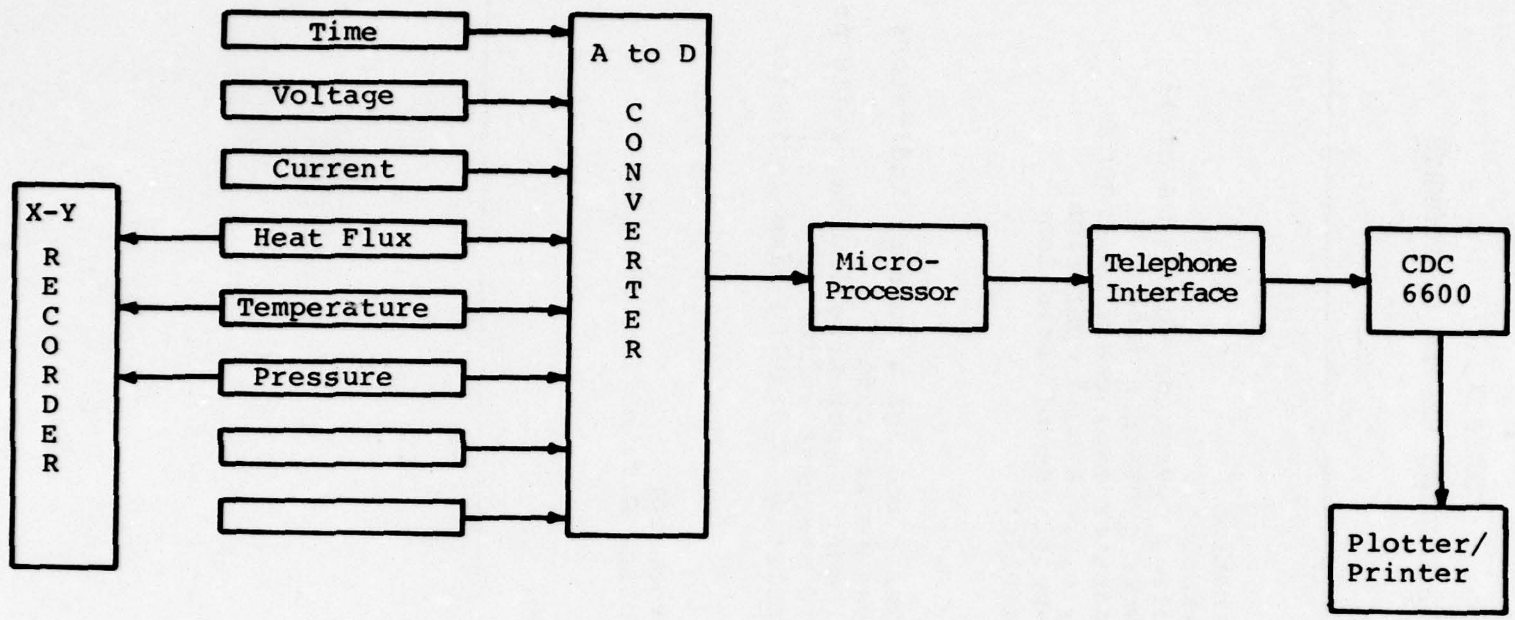

Figure 9. Data Acquisition System.

TABLE 7

DATA ACQUISITION SYSTEM COMPONENTS

Operating Controls
Wind tunnel operation
Quartz lamp operation
Quartz lamp cooling operation (blower & air)
Quartz lamp remote operation jack
Quartz lamp & shutter exposure time control
Computer reset, clock & hold operation
Controller set-point remote operation
Tri-phaser controller
Monitoring Controls
Quartz lamp power - voltage & current indicators
Wind tunnel pressure indicator
Peripheral equipment temperature indicator (10 pt.)
Shutter solenoid overheat indicator
Quartz lamp cumulative operating time indicator
Data Acquisition
LSI-11 micro-processor
Ectron differential D.C. amplifiers (8)
Power supply
Teletype
Acoustic coupler

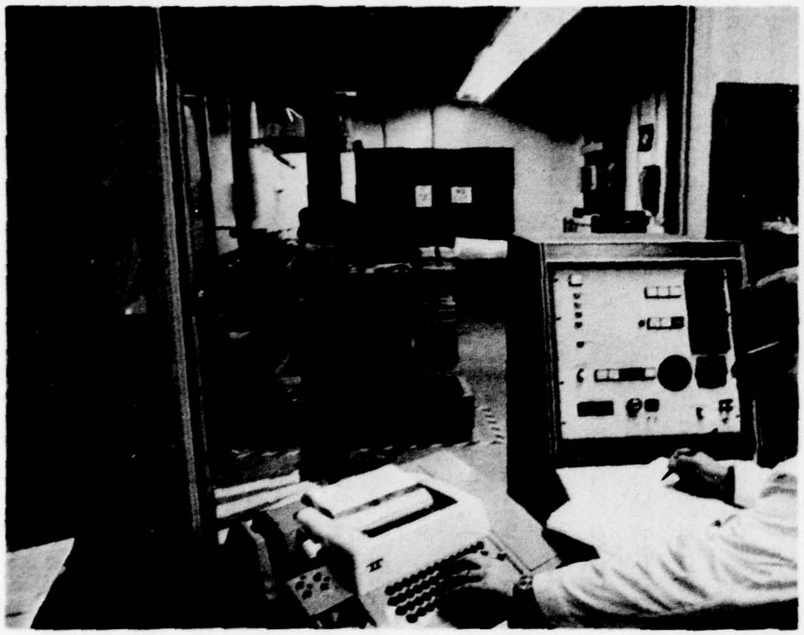

Figure 10 . Console.

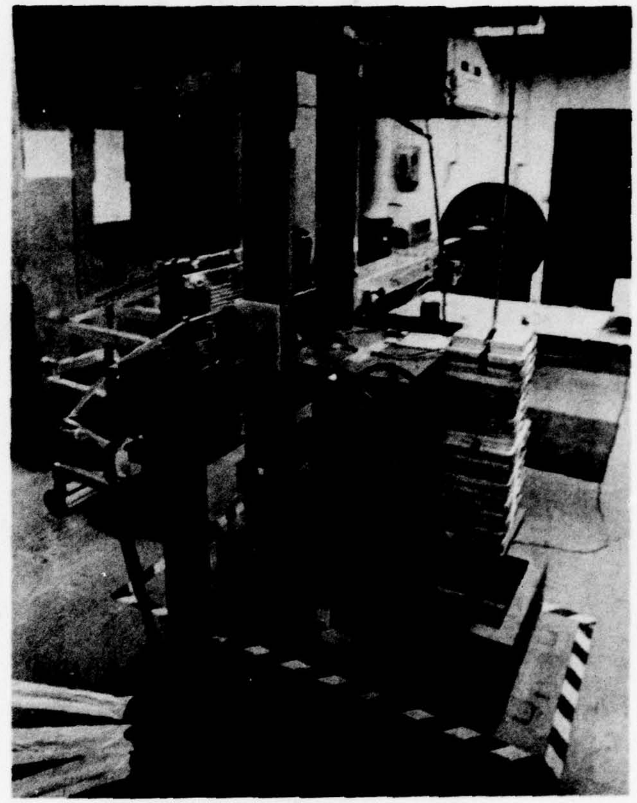

Figure 11 Thermal Flash Laboratory Overview.

SECTION 3
FACILITY UTILIZATION

3.1 TEST SCHEDULING

The Tri-Services Nuclear Flash Test Facility is available to governmental users on a no-charge basis. Test programs involving nuclear thermal flash materials performance receive priority although other tests may be accommodated; all test programs must be approved by the Defense Nuclear Agency contract monitor.

Specific details regarding test program procedures, scheduling, special testing requirements, specimen sizes, heat flux levels, etc., should be directed to the Test Director in charge of the Facility, Mr. Ben Wilt (513-229-2517). Note that the analysis of material performance must be conducted by the Facility user.

Material response tests for the Tri-Service community take precedence over all other activities associated with the operation of the Facility. That is, test requests have been scheduled at the test initiator's convenience if possible. Since most test programs are about one to five days in length, few conflicts in scheduling have arisen and few are anticipated. Based on experience, each new test program typically requires special planning and hardware (such as instrumentation and specimen mounting brackets); therefore, the more advance notice given for a particular test program the more efficiently the tests can be conducted. All test scheduling, special requirements, etc., have been and will be handled by the Test Director, Mr. Ben Wilt.

3.2 COMPLETED TEST PROGRAMS

The primary purpose of the Facility is to support the Tri-Service community with a quick-response, thermal nuclear flash, materials response testing capability. Tests which have been conducted are summarized in Table 8. Additional information on these tests can be obtained by contacting Mr. Ben Wilt and References 3-7. The specific runs are listed in the Appendix.

3.3 PROJECTED TEST PROGRAMS

Table 9 identifies the known tests to be conducted during the next 12 months. Since the primary purpose of the Facility involves quick-response testing, it is not possible to establish a comprehensive list of all future tests at this time.

TABLE 8

COMPLETED TEST PROGRAMS

Initiator	Org.	Project	Test Matl.	Test No.	Test Dates
Alexander	AVCO	DNA	1	001-073	March 7-10, 1977
Alexander	AVCO	DNA	1	074-086	March 15, 1977
Collis	Boeing	AWACS	2	087-316	March 21-24, 1977
Graham	AVCO	DNA	3	359-416	June 6-16, 1977
Alexander	AVCO	DNA	4	419-574	June 20-24, 1977
Collis	Boeing	ALCM	5	576-677	July 19-22, 1977
Alexander	AVCO	DNA	4	678-772	October 5-7, 1977
Grady	AVCO	DNA	6	773-855	October 12-22, 1977
Rhodehamel	AFML	ILAAMT	7	856-870	October 31, 1977
Collis	Boeing	ALCM	5	871-1076	July 10-14, 1978
Sparling	Rockwell	DNA	8	1081-2572	July 28-Sept. 28, 1978
Worscheck	Convair	ALCM	9	2573-2677	October 2-4, 1978
Sparling	Rockwell	DNA	8	2711-3235	October 24-31, 1978

MATERIAL DESCRIPTIONS

1. Aluminum, glass epoxy, or graphite epoxy substructure with multilayer coatings including primer MIL-P-2337, unpigmented polyurethane resin and pigmented polyurethane topcoat (aerodynamic load).

2. Aluminum, epoxy-fiberglass, magnesium, or epoxy-graphite honeycomb substructures with enamel MIL-C-8326, astrocoat black/white, or fluorocarbon black/white coatings (aerodynamic load).

3. Quartz polyimide and graphite epoxy tensile specimens (no load).

4. Two-layer antistatic aluminized polyurethane coatings, white silicone coatings, three-layer fluoroelastomer coatings, copper foil coatings, flame-sprayed aluminum, teflon, cork silicone, white epoxy polyimides, Grafoil coating over 6061 aluminum, quartz polyimide, or graphite epoxy substructures (aerodynamic load).

5. Aluminum or epoxy-fiberglass honeycomb substructures with primer MIL-P-23377 and enamel MIL-C-83286, astrocoat-primer plus erosion coating 8001 plus white topcoat 8004 or combinations of those coatings (aerodynamic load).

TABLE 8

COMPLETED TEST PROGRAMS (Concluded)

MATERIAL DESCRIPTIONS (Continued)

6. Quartz polyimide and graphite epoxy tensile specimens (tensile load).

7. Aluminum specimens with grey polymeric bead coating.

8. Glass-epoxy, glass-polyimide, quartz-epoxy, graphite-epoxy, graphite-polyimide, Kevlar-epoxy, and boron-epoxy multi-layers over honeycomb substructures coated with MIL-C-83286 aliphatic polyurethane (white) over MIL-P-83277 primer.

9. Aluminum, glass-epoxy substrates with MIL-P-23377 primer, MIL-C-81773 coatings over MIL-P-23377 primer, Mask 10A over MIL-P-23377 primer, Mask 10A over MIL-C-81773 coating and MIL-P-23377 primer.

Note that a more comprehensive description of the materials which have been tested is contained in the Appendix; additional information on the materials can be obtained from the Defense Nuclear Agency Contract Monitor, the test initiator, or from the University of Dayton Test Director.

TABLE 9

PROJECTED TEST PROGRAMS

Initiator	Organization	Project	Material	Date
Sparling	Rockwell	DNA	Aircraft Coatings	November
Baba	Harry Diamond Labs	DOA	Electrical Components	December
Alexander	AVCO	DNA	Aircraft Coatings	December
Rhodehamel	AFML	ILAAMT	Graphite Epoxies	January
Evans	U.S. Army Ballistics	DOA	Paints and Coatings	January
Worscheck	Convair	ALCM	Missile Protection	February

SECTION 4

PROJECTED FACILITY DEVELOPMENT

Keeping the Tri-Services Thermal Flash Facility operational and current is an ongoing activity. Periodic maintenance typically includes quartz lamp replacement, instrumentation calibration, and related activities. Updating the Facility is also an important task. Projected improvements are summarized below, with the primary emphasis on photographing specimen deterioration during testing. These improvements will be conducted between test programs during FY79 and FY80.

Surface Phenomena Photography - Motion picture photography of surface degradation would be an asset to data analysis. Although this procedure is relatively straightforward, the proper placement of the equipment, choice of lenses and filters, etc., must be perfected.

Surface Temperature Pyrometry - A recording optical pyrometer system is available which can be used to measure the high surface temperature of test specimens. Although the procedure is straightforward, there are physical constraints which limit the placement of the pyrometer sensing head. Some modifications will be required.

Flow Improvement - The flow in the wind tunnel is not uniform, complicating the analysis of materials for which the performance is strongly dependent upon surface shear. Screens, inlet shape, and other approaches will be investigated in order to achieve a more uniform surface shear in the wind tunnel.

Solar Furnace - The solar furnace is located in the laboratory but must be wired up and checked out. The furnace uses a carbon arc for the radiation source more closely simulating the nuclear flash black body temperatures and also allowing for wavelength variation effects on material performance.

Simultaneous Aerodynamic and Mechanical Loading - The ability to simultaneously expose materials to radiant heating, aerodynamic shear, and mechanical loading is obviously desirable. Approaches for implementing this type of test will be investigated.

SECTION 5
SUMMARY

The Tri-Services Thermal Nuclear Flash Test Facility for investigating the effects of thermal radiation on materials has been established. The Facility is located at the USAF Materials Laboratory, Wright-Patterson AFB, Ohio. The capability for irradiating specimens to intense thermal radiation, including the effects of aerodynamic loads or mechanical loads is operational. Three thousand two hundred thirty-five (3,235) tests have been conducted for the Tri-Service community at this time. A large number of additional tests are scheduled during the next 12 months; additional improvements to the Facility are planned, with an emphasis on photographing specimen deterioration during the exposure to intense radiation heating.

REFERENCES

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APPENDIX

THERMAL FLASH TESTS

Run Series	Specimen Configurations: Substructures	Coatings
001-073	Aluminum 6061	WMS-0; WMS-4; WMS-7; CMS-905; WMS-0/CMS-905; WMS-4/CMS-905; WMS-7/CMS-905; 1224-0; CMS-6231
	Glass-Epoxy	WMS-0/CMS-905; WMS-7/CMS-905; CMS-905; CMS-6231
	Graphite-Epoxy	WMS-0/CMS-905; WMS-4/CMS-905; WMS-7/CMS-905; 1224-4/CMS-905; 1224-0; CMS-905
074-086	Graphite-Epoxy	WMS-0; WMS-4; WMS-7/CMS-905; WMS-7/CMS-6231; CMS-6231
087-316	Glass-Epoxy Honeycomb	MIL-C-8326; MIL-L-81352; MIL-C-83281; MIL-C-83286; Astrocoat; Fluorocarbon; Polysulfide
	Aluminum Honeycomb	MIL-C-8326; MIL-C-83286
	Graphite-Epoxy TBD Honeycomb	MIL-C-83281; MIL-C-83286
	Aluminum Sheet	MIL-C-83281; MIL-C-83286
	Magnesium Sheet	MIL-C-83281; MIL-C-83286
317-360	FACILITY MODIFICATION AND CALIBRATION	
361-412	Quartz Polyimide	Uncoated
	Graphite-Epoxy	Uncoated
419-574	Glass-Epoxy (Table I)	1; 2; 3; 4A; 4B; 5A; 5B; 5C; 5D; 6; 7; 8A; 8B; 8C; 9; 9B; 10; 11; 12A; 12B; 13A; 13B; 15A; 15B; 16; 17
	Graphite-Epoxy (Table I)	1; 2; 3; 4; 5; 5B; 5C; 6; 7; 8B; 9A; 9B; 10; 11; 12A; 12B; 13A; 13B; 15A; 16; 17
	Quartz Polyimide (Table I)	1; 2; 3; 4A; 4B; 5A; 5B; 5C; 5E; 9A; 10; 12A; 15A; 15B; 16; 17

Run Series	Specimen Configurations Substructures		Coatings
	Aluminum 6061	(Table I)	2; 6; 7; 12; 18; 19; 20; 21
575-677	Glass-Epoxy Honeycomb	(Table I)	25; 26; 28; 29; 30; 31; 32; 33
	Aluminum Honeycomb	(Table I)	25; 26; 27
	Aluminum Sheet	(Table I)	25; 26; 27
688-772	Glass-Epoxy	(Table I)	1; 2; 3; 4B; 5A; 5B; 5C; 5D; 7; 9A; 10; 10B; 15A; 24
	Graphite-Epoxy	(Table I)	4B; 6; 9A; 9C; 10; 10B; 10C; 11A; 12A; 12C; 12D; 14; 15B; 22; 23
	Quartz Polyimide	(Table I)	0; 4B; 5; 5B; 5C; 9A; 10A; 10B; 12A; 12C; 12D; 14; 15A
773-855	Graphite-Epoxy		White polyimide; cork silicone; uncoated (All tested in tension)
	Quartz Polyimide		White polyimide; cork silicone; uncoated (All tested in tension)
856-870	Aluminum		Grey polymeric bead
871-1076	Epoxy-fiberglass Foam sandwich		(Table I) 34; 35; 36
	Epoxy-fiberglass Honeycomb sandwich		(Table I) 35; 37
	Graphite-epoxy		(Table I) 38; 39; 40
	Natural polyethylene with honeycomb core		No coating
	White polyethylene with honeycomb core		No coating

Run Series	Specimen Configurations Substructures	Coatings
	Delrin with Flex-core Honeycomb	No coating
	Nylon with Flex-core Honeycomb	No coating
1081-2571	Honeycomb Substructure	(Table I) 41; 42; 43; 44; 45; 46; 47; 48; 49; 50; 51; 52; 53; 54
2572-2677	Aluminum 7075	(Table I) 55; 56; 57; 58; 59; 60; 61; 62; 63; Anodize
	Glass-epoxy	(Table I) 55; 56; 57; 58; 59; 60; 61; 62; 63; Uncoated
2678-2710	FACILITY MODIFICATION AND CALIBRATION	
2711-3235	Honeycomb Substructure	(Table I) 41; 42; 43; 44; 45; 46; 47; 48; 49; 50; 51; 52; 53; 54

TABLE I

TABLE OF MATERIALS

1	Two-layer anti-static white polyurethane
2	Single-layer aluminized polyurethane
3	White MIL-C-83286 over aluminized polyurethane
4A	Dow 808 white silicone, 50 PVC titania
4B	Dow 808 white silicone, 25 PVC titania
5A	Three layer white fluorocarbon, 40 PVC titania plus fibers
5B	Three layer white fluorocarbon, 25 PVC titania plus fibers
5C	Three layer fluorocarbon erosion coating, 25 PVC titania plus fibers
5D	Three layer fluorocarbon erosion coating, 40 PVC titania plus fibers
6	Bonded copper foil, 2 Mil
7	Flame sprayed aluminum
8A	Bonded polyester film, 10 Mil
8B	Bonded TFE teflon film, 10 Mil
8C	Bonded UHMW polyethylene film, 10 Mil
9A	Bonded cork silicone, 20 Mil
9B	Bonded cork silicone, 50 Mil
9C	Cork silicone, 10 Mil
10A	Epoxy-polyimide white ablative paint
10B	Epoxy-polyimide flexible white, 6 Mil
10C	Epoxy-polyimide flexible white, 10 Mil
11	Grafoil stitched package
12A	Bonded RTV 655 silicone, 20 Mil
12B	Bonded RTV 655 silicone, 50 Mil
12C	Modified RTV 655, white, sprayed, 10 Mil
12D	Modified RTV 655, white, sprayed, 3 Mil
13A	Bonded silastic 23510 white silicone, 20 Mil
13B	Bonded silastic 23510 white silicone, 50 Mil
14	RTV-655, 3 Mil over cork silicone, 10 Mil
15A	134/KHDA polyurethane erosion coating, 5 PVC titania
15B	134/KHDA polyurethane erosion coating, 25 PVC titania

TABLE I

TABLE OF MATERIALS (Continued)

16	Desoto 10A grey polyurethane topcoat over aluminized polyurethane
17	Bostic dark grey polyurethane over aluminized polyurethane
18-21	Grey polyurethane
22	White RTV 655, 3 Mil over conductive RTV 3 Mil
23	Bonded aluminum foil, 2.4 Mil
24	Bonded aluminum foil with topcoat, 2.4 Mil
25	MIL-P-23377 primer plus white MIL-C-83286 enamel (Desoto)
26	Same as "25" except thicker enamel
27	Same as "25" except very thick enamel
28	Astrocoat system; primer plus white 8001 erosion coating plus white (non-yellowing) 8004 topcoat
29	Same as "28" but the 8001 coating is thicker
30	Astrocoat system; primer plus white (non-yellowing) 8004 topcoat
31	Astrocoat system; primer plus white 8001 erosion coating plus black 8003 antistatic topcoat
32	Same as "31" except thicker 8001 coating
33	Same as "25" except DEFT white enamel per MIL-C-83286
34	2-ply 120 fabric prepreg
35	2-ply 181 fabric prepreg
36	3-ply 181 fabric prepreg
37	5-ply 120 fabric prepreg
38	5-ply skin with chopped fiber-epoxy
39	2-ply skin with chopped fiber-epoxy

TABLE I

TABLE OF MATERIALS (Continued)

40	5-ply skin with chopped graphite fiber bonded to titanium
41	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 7781 glass reinforced F-161 epoxy (3, 4, 5, and 6 plies)
42	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 7781 glass reinforced CE-9000 epoxy (3, 4, 5, and 6 plies)
43	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 7781 glass reinforced F-178 addition polyimide (3, 4, 5, and 6 plies)
44	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 7781 glass reinforced 2272 addition polyimide (3, 4, 5, and 6 plies)
45	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 581 quartz reinforced F-161 epoxy (3, 4, 5, and 6 plies)
46	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 581 quartz reinforced F-178 addition polyimide (3, 4, 5, and 6 plies)
47	MIL-C-83286 white polyurethane, MIL-P-83277 primer over T-300 graphite reinforced 5208 epoxy (3, 4, 5, and 6 plies)
48	MIL-C-83286 white polyurethane, MIL-P-83277 primer over AS graphite reinforced 3501-5A epoxy (3, 4, 5, and 6 plies)
49	MIL-C-83286 white polyurethane, MIL-P-83277 primer over AS graphite reinforced 934 epoxy (3, 4, 5, and 6 plies)
50	MIL-C-83286 white polyurethane, MIL-P-83277 primer over AS graphite reinforced F-178 addition polyimide (3, 4, 5, and 6 plies)
51	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 181 Kevlar reinforced 5208 epoxy (3, 4, 5, and 6 plies)
52	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 181 Kevlar reinforced F-161 epoxy (3, 4, 5, and 6 plies)
53	MIL-C-83286 white polyurethane, MIL-P-83277 primer over 181 Kevlar reinforced 934 epoxy (3, 4, 5, and 6 plies)
54	MIL-C-83286 white polyurethane, MIL-P-83277 primer over boron-epoxy (3, 4, 5, and 6 plies)

TABLE I

TABLE OF MATERIALS (Concluded)

55	MIL-P-23377 primer
56	MIL-C-81773 coating 37875 over MIL-P-23377 primer
57	MIL-C-81773 coating 36622 over MIL-P-23377 primer
58	MIL-C-81773 coating 36314 over MIL-P-23377 primer
59	MIL-C-81773 coating 17875 over MIL-P-23377 primer
60	MIL-C-83286 coating 30140 over MIL-P-23377 primer
61	Mask 10A over MIL-P-23377 primer
62	Mask 10A over MIL-C-81773 coating 17875 over MIL-P-23377 primer
63	Mask 10A over MIL-C-81773 coating 37875 over MIL-P-23377 primer

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